Abstracts of Technical Articles from Bell System Sources

The Thermionic Work Function and the Slope and Intercept of Richardson Plots.[1] J. A. BECKER and W. H. BRATTAIN. This article is a critical correlation of the slope and intercept of experimental Richardson lines with the quantities appearing in *theoretical* equations based on thermodynamic and statistical reasoning. The equation for *experimental* Richardson lines is $\log i - 2 \log T = \log A - b/2.3\,T$; A and b are constants characteristic of the surface, i is the electron emission current in amp./cm.^{2}, T is the temperature in degrees K, $\log A$ is the intercept and $-b/2.3$ is the slope of experimental lines. Statistical *theory* based on the Fermi-Dirac distribution of electron velocities in the metal shows that i should be given by $\log i - 2 \log T = \log U(1 - r) - w/2.3\,T$, where U is a universal constant which has the value 120 amp./cm.^{2} °K^2, r is the reflection coefficient, and w is the *work function.* A correlation of the experimental and theoretical equations shows that $b = w - Tdw/dt$, and $\log A = \log U(1 - r) - (1/2.3)dw/dT$. Only when r is 0 and the work function is independent of the temperature, is it correct to say that the slope is $-w/2.3$ and that the intercept has the universal value $\log U$. But even when w is a function of T, it follows from a thermodynamic argument that the slope is given by $-h/2.3$, where the heat function h is defined by $h = (L_p/R) - (5/2)T$, L_p is the heat of vaporization per mol at constant pressure. The heat function is related to the work function by the equation $h = w - Tdw/dT$.

From experimental and theoretical arguments it is deduced that the reflection coefficient is probably negligibly small. Hence we conclude that *for most surfaces the work function varies with temperature,* since the intercepts of Richardson lines are rarely equal to log 120. This conclusion is to be expected since on Sommerfeld's theory, w depends on the number of free electrons or atoms per cm.^{3}, which in turn varies with temperature due to thermal expansion.

The photoelectric work function should equal the thermionic work function but should not in general be equal to -2.3 times the slope of the Richardson line. The Volta potential between two surfaces having work functions w_1 and w_2 should equal $(w_1 - w_2)k/e$ rather than $2.3k/e$ times the difference between the slopes of the Richardson lines for the two surfaces. The data from photoelectric and Volta potential meas-

[1] *Phys. Rev.*, May 15, 1934.

urements support the conclusion that the work function depends on temperature.

Fundamental Concepts in the Theory of Probability.[2] THORNTON C. FRY. Three commonly accepted definitions of the word "probability" are discussed critically, with regard both to logical soundness and to practical utility. Two major theses are presented: first, that each definition has utilitarian merits which render it especially valuable within its own field; second, that the objection of logical redundancy which is so frequently raised against the Laplacian definition can equally well be raised against the other two definitions.

Wide-Range Recording.[3] F. L. HOPPER. The recent improvements in sound quality resulting from the extension of the frequency and intensity ranges are the results of coordinated activity in recording equipment and processes, reproducing equipment, and theater acoustics. This paper discusses the recording phase of the process. A wide-range recording channel consists essentially of the moving-coil microphone, suitable amplifiers, a new recording lens, and certain electrical networks.

The characteristics of such a system, from the microphone to and including the processed film, are shown. Other factors fundamentally associated with wide-range recording, such as monitoring, film processing, the selection of takes in the review room, and re-recording, are also discussed. The changes brought about by this system of recording result, first, in a greater freedom of expression and action on the part of the actor; and, second, in a much greater degree of naturalness and fidelity than has been previously achieved.

Iron Shielding for Telephone Cables.[4] H. R. MOORE. Voltages of fundamental and harmonic frequencies, induced along communication cables by neighboring power or electric railway systems, can be reduced by the electromagnetic shielding action of the sheath, if this is grounded continuously or at the ends of the exposure. The shielding, particularly at the fundamental frequency, is improved greatly by the provision of a steel tape armor, while a surrounding iron pipe conduit effects a very great improvement at both the fundamental frequency and the higher harmonics.

This paper presents methods for the quantitative prediction of the shielding, expressed by a "shield factor" or the fraction to which

[2] *American Mathematical Monthly*, April, 1934.
[3] *Jour. S. M. P. E.*, April, 1934.
[4] *Electrical Engineering*, February, 1934.

a disturbing voltage is reduced. Necessary impedance data are given for numerous iron-surrounded cable constructions and working charts are supplied for the convenient determination of the shielding obtainable with commercially available steel tape armored cables.

On the basis of data presented in this paper, prediction of the shielding to be obtained from steel tape armored cable sheaths or those inclosed in iron pipes is concluded to be both feasible and practical. With internal impedances measurable on short length samples of a chosen construction, the accuracy of prediction is limited principally by the precision to which the disturbing field and the grounding resistances of the cable sheath may be determined. Either of the constructions discussed is capable of effecting a high order of shielding against low frequency induction and practically complete protection from harmonic disturbances. Field observations on installed cables, both tape armored and in pipe conduit, have verified the computational methods presented.

Propagation of High-Frequency Currents in Ground Return Circuits.[5] W. H. Wise. The electric field parallel to a ground return circuit is calculated without assuming that the frequency is so low that polarization currents in the ground may be neglected. It is found that the polarization currents may be included by replacing the r in Carson's well-known formulas by $r\sqrt{li(\epsilon - 1)/2c\lambda\sigma}$. The problem to be solved is that of calculating the electric field parallel to an alternating current flowing in a straight, infinitely long wire placed above and parallel to a plane homogeneous earth. Carson's derivation of this field is based on three restricting assumptions: (1) The ground permeability is unity; (2) the wave is propagated with the velocity of light and without attenuation; (3) the frequency is so low that polarization currents may be neglected. The first of these restrictions is usually of no consequence and the formula would be quite complicated if the permeability were not made unity. As pointed out in a later paper by Carson, the second restriction amounts merely to assuming reasonably efficient transmission. The effect of the third restriction begins to be noticeable at about 60 kilocycles. The object of the present paper is the removal of the third restriction.

Acoustical Requirements for Wide-Range Reproduction of Sound.[6] S. K. Wolf. The extension of the frequency and volume ranges in recording and reproducing sound has aroused a greater and more critical

[5] *Proc. I. R. E.*, April, 1934.
[6] *Jour. S. M. P. E.*, April, 1934.

consciousness of the importance of theater acoustics. It follows that higher fidelity in reproduction excites greater intolerance of the needless distortion caused by poor acoustics of the theater. To cope with the new situation, engineers have developed new instruments for acoustical analysis, which provide greater precision and facility in detecting defects and in determining the necessary corrections.

In addition to instrumental developments there have been concurrent advances in acoustical theory and practice. The result is that the more stringent requirements imposed on the acoustics of the theater by the enlarged frequency and volume ranges can be fulfilled adequately and practically. The paper discusses the requirements and describes some of the available methods for complying with them.